PUERTO RICO EXPERIMENT STATION
of the
UNITED STATES DEPARTMENT OF AGRICULTURE
MAYAGUEZ, PUERTO RICO

REPORT OF THE PUERTO RICO EXPERIMENT STATION

1935

Issued July 1936

UNITED STATES DEPARTMENT OF AGRICULTURE
OFFICE OF EXPERIMENT STATIONS

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PUERTO RICO EXPERIMENT STATION

[Administered by the Office of Experiment Stations, U. S. Department of Agriculture]

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INTRODUCTION

In May 1934, Rexford G. Tugwell, Under Secretary of the United States Department of Agriculture, visited the Puerto Rico Experiment Station (fig. 1) and suggested a number of important changes in policies and objectives. As a result of his suggestions the agricultural situation has been reviewed not only with the economic reconstruction of Puerto Rico in view, but also with the purpose of exploring the means by which a tropical station such as this may best serve the Department of Agriculture and agriculture in the continental United States as a whole.

An important objective of this report will be the presentation of such a review, setting forth some of the factors and natural assets which might be utilized in working toward a successful Puerto Rican agriculture. Consideration of these factors, it is believed, will contribute effectively not only to a more prosperous Puerto Rico, with higher standards of living, but also to an agriculture complementary to and not competitive with that of the continental United States.

RELATIONSHIP OF POPULATION TO AGRICULTURAL PROBLEMS

Puerto Rico one of the most densely populated countries of the Western Hemisphere.

Table 1, showing the population, total areas, arable land, and population per square mile, was prepared from figures of the U. S. Census Bureau, 1935, and the World Almanac for 1934. This

FIGURE 1.—Laboratory and office building of the Puerto Rico Experiment Station of the United States Department of Agriculture at Mayaguez, P. R., as it appeared on June 30, 1935. The photograph serves to show some of the rare palms collected from many different countries and comprising part of the more than 2,000 plant introductions made in the history of the station. It has been said that this station has the largest collection of tropical plants in the Western Hemisphere and the best recorded.

tabulation shows the comparatively high density of population in the island which constitutes one of the most important factors bearing on the directions to be taken by Puerto Rican agriculture.

TABLE 1.—*Population, total area, arable land, and arable land per person, of Puerto Rico as compared with other countries and regions*

Country	Population	Total area	Population per square mile	Arable land	Arable land per person
		Square miles		*Acres*	*Acres*
Puerto Rico	1,722,994	3,339.5	501	1,222,284	0.70
Dominican Republic	1,200,000	19,325	62	9,920,000	8.26
Cuba	3,763,375	41,634	90	[1]	
Mexico	16,404,030	767,198	21	120,417,760	7.34
Guatemala	2,454,000	42,353	58	[1]	
El Salvador	1,459,578	13,173	111	[1]	
Costa Rica	527,690	23,000	23	[1]	
Nicaragua	750,000	49,200	15	[1]	
Panama	467,459	33,667	14	[1]	
Colombia	8,223,000	443,985	18.5	[1]	
Venezuela	3,216,000	393,976	8	[1]	
Brazil	41,079,000	3,285,319	12.5	[1]	
Trinidad	386,712	1,862	208	517,538	1.34
Barbados	172,182	166	1,037	74,000	.43
Rhode Island	687,497	1,248	551	279,361	.41
Massachusetts	4,249,614	8,266	514	2,005,461	.47
New York	12,965,000	49,204	263	[2] 18,090,006	1.39
Florida	1,468,211	58,666	25	[1]	
Ohio	6,646,697	41,040	162	[2] 21,514,059	3.24
Mississippi	2,009,821	46,865	43	[2] 17,348,432	8.63
Nevada	91,058	110,690	0.82	[2] 4,080,000	44.81
California	5,677,251	158,297	36	30,442,581	5.36
Hawaii	380,507	6,407	59	440,579	1.16
Netherlands	8,061,571	12,582	640.7	5,563,960	.69
Belgium	8,159,824	11,752	694.3	4,517,630	.55
British Isles	46,268,174	94,284	491	29,915,520	.65
Germany	65,300,000	185,889	351	51,206,167	.78
Italy	41,806,000	119,744	349	70,285,423	1.68
Spain	28,719,177	190,050	151	114,000,000	3.97
France	41,928,851	212,659	197	54,755,528	1.31
Japan	66,317,126	148,756	446	[3] 14,241,995	.21
Philippine Islands	12,604,100	114,400	110	39,657,000	3.15
Java	41,719,524	50,752	822	[1]	

[1] Not given. [2] In farms and buildings. [3] Planted in 1932.

Puerto Rico has less than 1 acre of arable land per person.

Of the total of 2,198,400 acres of land and inland bodies of water in Puerto Rico, 1,222,284 acres were recorded as arable by the 1930 census. This figure includes pasture land. Thus, there is approximately seven-tenths of an acre of arable land and pasture per person. In addition, there are 322,447 acres classed as woodland but which actually consist largely of cut-over land, at present covered with naturally occurring young growth. There are more than 600,000 acres of land in the island which cannot be classed as arable or as woodland and at the present time are considered as wasteland.

Few of world's densely populated countries depend solely upon agriculture.

It is a common impression that Puerto Rico is the most densely populated country in the Western Hemisphere. The foregoing tabulation, however, shows that Barbados has more than twice as many people per square mile as Puerto Rico. In the continental United States both Rhode Island and Massachusetts have considerably larger populations per square mile, and smaller areas of arable land per person than this island.

In Europe, both the Netherlands and Belgium have more people per square mile than Puerto Rico and less area of arable land per person.

In the Far East, Java has a population per square mile nearly twice as great as Puerto Rico. Japan has practically the same population per square mile of total area but almost four times as many persons per square mile of arable land. The most densely populated areas in the world are believed to be in southern China, but there are no accurate census figures for that country.

Of the foregoing States or countries with very high population per square mile, all are industrial countries with the exception of Barbados and Java: Puerto Rico is similar to both these countries in being dependent almost entirely upon agriculture for income. The agriculture of both Barbados and Java, however, is mostly of the large-plantation type in which the agricultural enterprises are frequently owned in the mother country and large numbers of the colonials are employed for the field work at comparatively low wages. The tendency in Puerto Rico is away from this type of agricultural enterprise and the objective is toward larger wages and improved standards of living for agricultural labor.

Crops of high value per acre are essential for Puerto Rico.

Puerto Rico, therefore, with population-pressure problems comparable with those of Barbados and Java, with a shortage of arable land, and with agriculture almost the sole source of income, has agricultural problems much more acute than in the continental United States.

The land-utilization problem of the island is further accentuated by a constantly increasing population. During the 10-year period from 1920 to 1930 the population increased 18.7 percent.

From the foregoing, the following conclusions seem evident:

With only a limited land area available per person studies could advantageously be directed toward finding and developing crops of high value per acre. Stated conversely, with but seven-tenths of an acre of land per person, crops of low average value per acre will result in low income and a consequent lowered standard of living.

It would seem logical to direct studies toward industrializing or processing in Puerto Rico some of its agricultural products.

The uses of irrigation and drainage as means of increasing the area of arable land are well known. However, there is another method of increasing arable land which results from the introduction of new economic plants and trials to determine their adaptability in situations impossible of utilization with commonly grown field or orchard crops. Further introductions of economic plants from other tropical countries and continued studies of the collections already made at the experiment station would seem to be one of the avenues for increasing areas of arable land in the island.

CLIMATIC FEATURES IN RELATION TO AGRICULTURE

Climate an important asset of Puerto Rico.

Table 2 shows average annual temperature, average maximum and minimum, and highest and lowest temperatures recorded at six representative Puerto Rican weather stations. As a basis of comparison

similar data are presented for nine stations of the continental United States.

TABLE 2.—*Temperature figures representative for Puerto Rico weather stations as compared with stations in the continental United States*

The records are from the Weather Bureau, U. S. Department of Agriculture, San Juan, P. R., figures represent records to and including 1930]

Station	Average annual temperature	Average annual maximum temperature	Average annual minimum temperature	Highest temperature recorded	Lowest temperature recorded [1]
	° F.	° F.	° F.	° F.	° F.
San Juan (north coast)	77.9	83.2	72.6	94	62
Isabela (northwest coast)	78.0	87.0	69.1	99	57
Mayaguez (west coast)	77.2	88.6	65.7	99	51
Ponce (semiarid south coast)	78.8	88.1	69.4	98	55
Fajardo (northeast coast)	79.4	86.1	72.7	98	57
Jayuya (central mountains)	74.6	86.8	62.4	98	46
Washington, D. C	54.8	64.3	46.1	106	**−15**
Boston, Mass	49.7	57.7	41.8	104	**−14**
New York, N. Y	52.1	59.6	45.0	102	**−13**
Chicago, Ill	49.1	56.5	41.7	103	**−23**
St. Louis, Mo	56.0	64.8	47.8	108	**−22**
Atlanta, Ga	61.3	69.9	52.7	103	**−8**
Jacksonville, Fla	69.2	77.5	61.0	104	**10**
New Orleans, La	69.4	76.8	62.0	102	**7**
Los Angeles, Calif	62.7	72.8	52.6	109	**28**

[1] Figures in bold face call attention to freezing temperatures of critical importance for truck-crop production.

Puerto Rico has 12 months of temperatures favorable for plant growth.

To students of economics, searching for natural advantages upon which Puerto Rico may base its reconstruction, the data in table 2 perhaps indicate one of the most important natural assets of the island. An elaboration of these data is shown more graphically in figure 2. From this figure it can be seen that Ponce, San Juan, and Mayaguez, three weather stations representative of the coastal regions

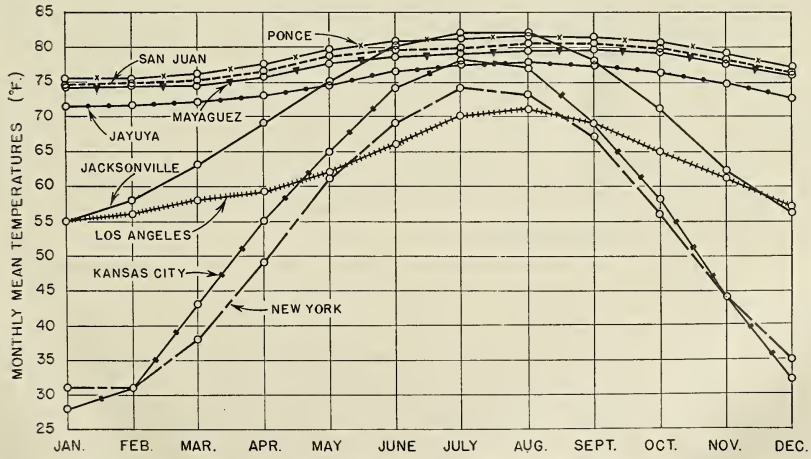

FIGURE 2.—Monthly mean temperatures at four Puerto Rican weather stations as compared with four stations in the continental United States.

of the island, have average monthly temperatures which in no case reach less than 74° F. Jayuya, which is situated in the mountains, has no average monthly temperature colder than 71° and is one of the coldest weather stations in Puerto Rico.

In contrast to this, the monthly mean temperatures for New York, Kansas City, Los Angeles, and Jacksonville are shown on the same graph in figure 2. Kansas City and New York, representative of the central and northern United States, have 2 months when the mean temperatures are lower than freezing. Los Angeles has a remarkably even monthly mean temperature curve for a temperate country. It is interesting to note that the mean monthly temperatures for Jacksonville in July and August are warmer than at any weather station in Puerto Rico.

These temperature curves indicate 12 months of growing weather in Puerto Rico with continuous periods of temperatures favorable for active growth. The mainland agricultural regions, on the other hand, are limited to 8 or even 6 months of growing temperatures. In some regions and for some crops there are only 2 or 3 months of temperatures most suitable for plant growth.

The figures for highest temperatures recorded are of interest not only to agriculturists but to vacationists seeking to avoid hot weather.

Freedom from frosts favorable for growing winter crops.

Complete freedom of Puerto Rico from frosts indicates the advantages of investigations to produce and market winter vegetables for the continental United States and other markets. The further advantage of tariff-free entry for such produce into the continental United States, and the need for crops of high value per acre due to the density of population, make such investigations appear logical.

Puerto Rico station can aid in continental corn-breeding program.

The curves showing mean monthly temperatures in the continental United States in comparison with temperatures in Puerto Rico also indicate an avenue of service in which the station may aid in some of the problems of continental agriculture. With the temperatures recorded in figure 2, the station grows three crops of corn a year; low temperatures have never in the history of the station been a factor at any time of the year in preventing corn production.

Arrangements are now being perfected with the Bureau of Plant Industry of the United States Department of Agriculture for the station to grow winter crops of their hybrid corn lines, doubling and possibly trebling the progress to be obtained in the corn-breeding programs. Similar arrangements are being considered to aid the cotton-breeding program of the Bureau of Plant Industry in the continental United States.

The possibility of accelerating a plant-breeding program to meet some new insect or disease scourge would seem to be of national importance.

Knowledge of hurricane liability essential to agricultural projects.

The maps of the Weather Bureau, United States Department of Agriculture, indicate that during the 10-year period 1924–33 three hurricanes of high intensity passed over parts of Puerto Rico. Several other hurricanes passed sufficiently close to result in the deluges of rainfall which accompany tropical hurricanes.

On September 13, 1928, a hurricane passed across the island from southeast to northwest during which wind velocities of 150 miles per hour were registered. During this hurricane the rain gage at Adjuntas registered a rainfall of 29 inches, which is a representative rain to be expected to accompany some of the worst tropical hurricanes. On September 10, 1931, a hurricane passed over the northern coast of Puerto Rico. During this hurricane a wind velocity of 90 miles per hour was recorded. On September 26, 1932, a hurricane again passed across the north coast of the island from east to west, during which wind velocities reached 129 miles per hour. During this hurricane 16.7 inches of rainfall during 24 hours was recorded in Maricao.

Most coffee-producing countries do not have hurricane liability.

The record of these three hurricanes in 10 years perhaps may give an exaggerated importance to the hurricanes. From 1825 to 1935, a period of 110 years, there have been but 9 highly destructive hurricanes recorded, or an average of 1 severe hurricane approximately every 12 years. Nevertheless, the hurricane liability is a factor in Puerto Rican agriculture which is important for such tree crops as rubber, coconuts, coffee, citrus, and cacao, and which is a liability not found, or is much less serious, in tropical countries nearer the Equator such as Brazil, Colombia, Venezuela, Java, Ceylon, and the Federated Malay States.

Hurricane damage to orchard crops more costly than to annual crops.

Where a hurricane liability exists, as in Puerto Rico, the conclusion would be that studies on use of low-lying crops, or annual crops involving small capital investment, are essential.

In the case of orchard, or certain other types of perennial crops, requiring 3 to 8 years to come to maturity, there is an accumulation of taxes, interest, and cultivation charges during the nonproductive period which results in a considerable capital investment by the time such crops come into production. Thus a hurricane may completely destroy an accumulated capital in the case of orchard or certain perennial crops which would not occur in the case of an annual crop.

In some cases, high values per acre might justify the hurricane risk on orchard or perennial crops. Studies at the station indicate that arroyos, at present largely nonarable, might be utilized for such perennial or orchard crops, and that the arroyos would afford considerable protection to tree crops susceptible to hurricane damage.

Puerto Rico in general has heavier rainfall than continental United States.

During the year it has been possible to make a considerable study of the comparative rainfall at different recording stations of the island. Charts have been prepared showing graphically the rainfall at each of these stations. Figures 3 to 6 show the nature of the studies. In figure 3, a graph showing the rainfall at Washington, D. C., averaged for 50 years, is presented as a basis of comparison of rainfall in a well-known continental area with rainfall stations in Puerto Rico. Figures 3, 4, 5, and 6 also show the average rain-

fall at San Juan, Rio Piedras, Aguirre, Ensenada, Mayaguez, Maricao, Lares, Isabela, Manati, Bayamon, and Rio Grande.

The charts show the rainfall at these stations as averaged by 14-day periods. The graphs are based on records of the Weather Bureau, United States Department of Agriculture, for 20 years or

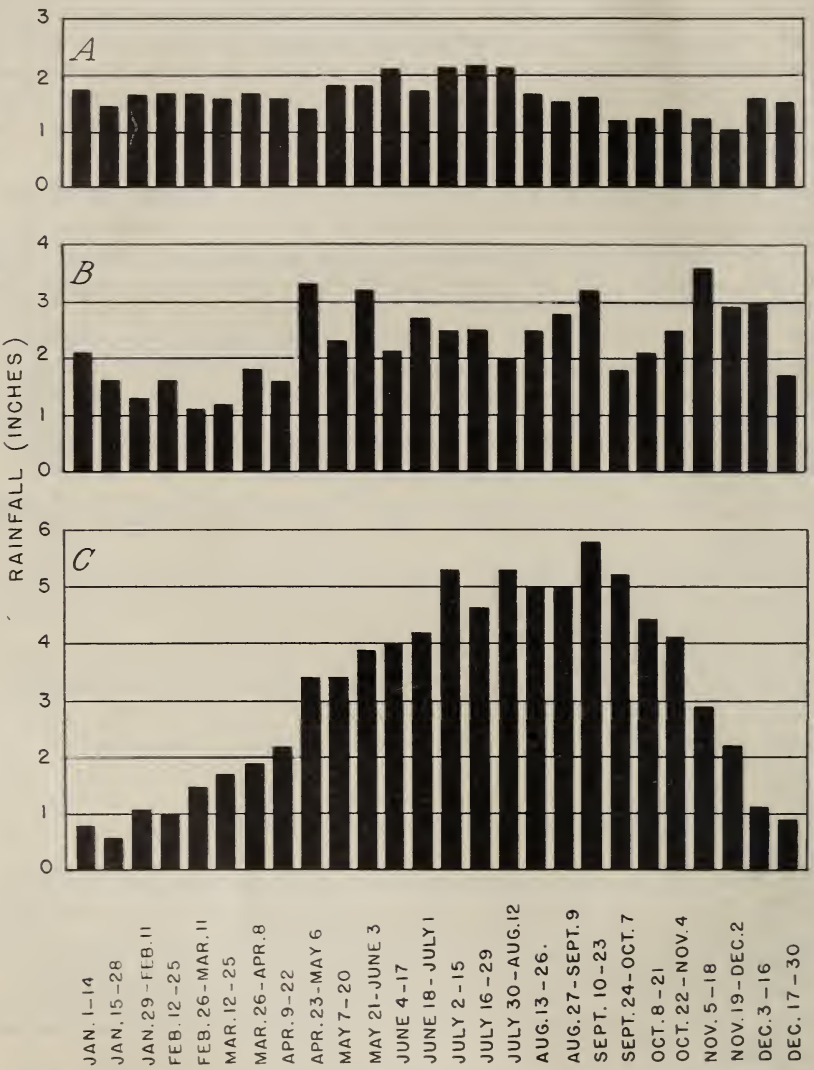

FIGURE 3.—Rainfall distribution at: *A*, Washington, D. C., based on records averaged for 50 years, average annual total rainfall 42.16 inches; *B*, San Juan, P. R., based on records averaged for 24 years, average annual total rainfall 59 inches; *C*, Mayaguez, P. R., based on records averaged for 24 years, average annual total rainfall 81.5 inches.

more. They show that Puerto Rico stations in general have a much larger annual rainfall than is common in the continental United States. Mayaguez, with 81.5 inches, has almost twice as much rain annually as Washington, D. C. Maricao has almost three times as much rain as Washington.

Semiarid areas exist as well as intense rainfall areas.

A comparison of the rainfall at Maricao with that at Ensenada shows some of the extremes of rainfall in the island; Ensenada is

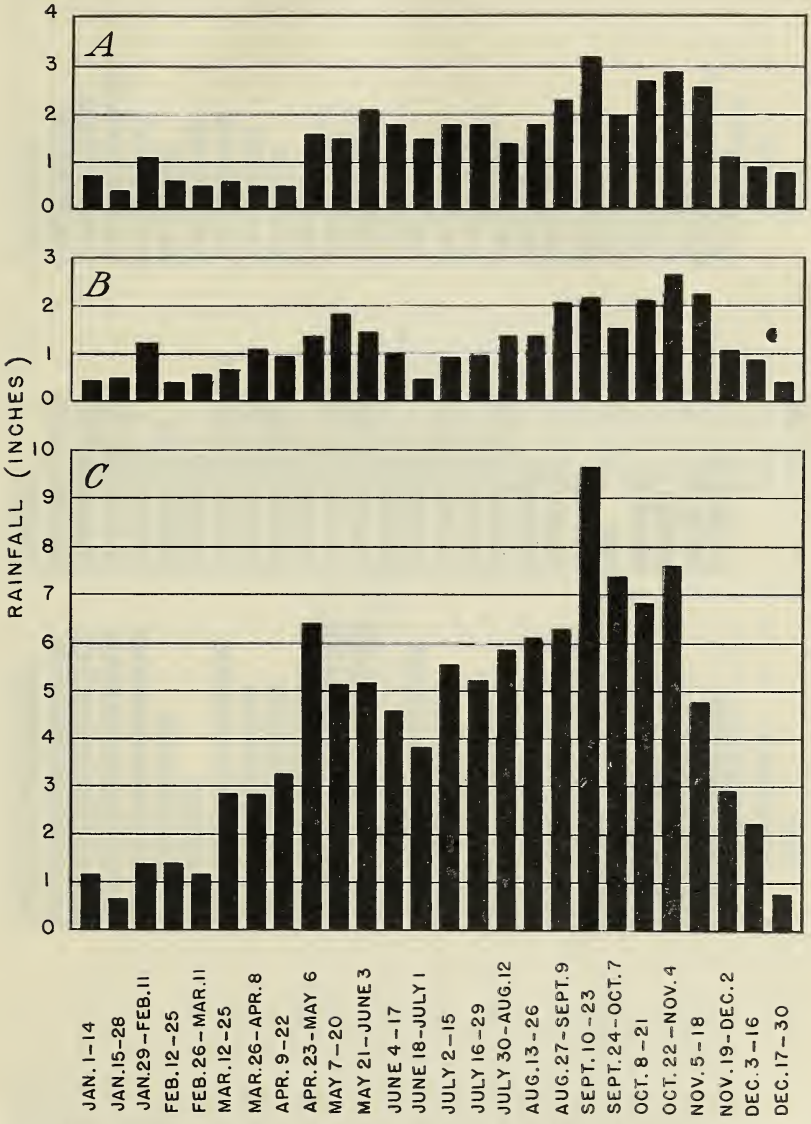

FIGURE 4.—Rainfall distribution at three rain-recording stations in Puerto Rico: *A*, Aguirre, based on records averaged for 24 years, average annual total rainfall 38.7 inches; *B*, Ensenada, based on records averaged for 22 years, average annual total rainfall 31.46 inches; *C*, Maricao, based on records averaged for 20 years, average annual total rainfall 110.88 inches.

but 25 miles from Maricao, but the average rainfall of Ensenada for 20 years is but 31.46 inches per year, as compared with an average annual rainfall at Maricao of 110.88 inches.

The great differences in total amounts of rainfall at these Puerto Rican stations can be attributed to the relation of topography to wind directions and velocities. The prevailing winds are east, north-

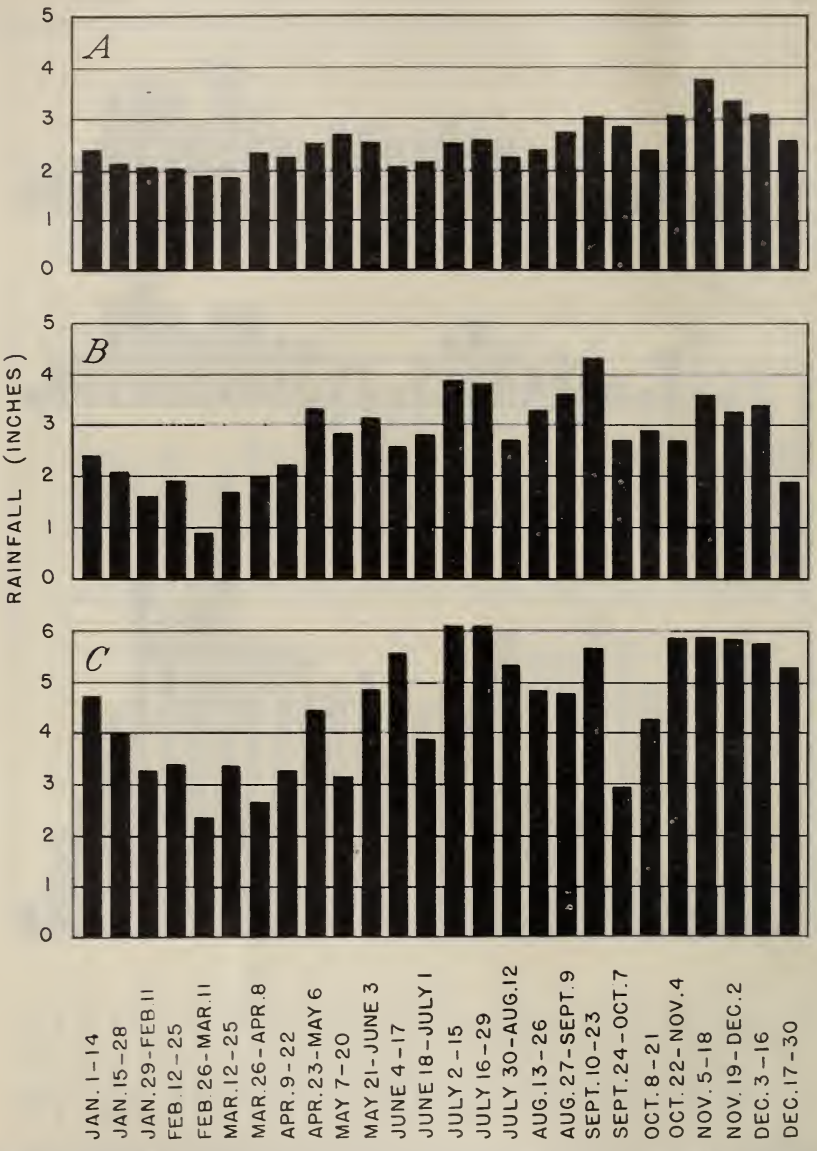

FIGURE 5.—Rainfall distribution of three rain-recording stations in Puerto Rico: *A*, Manati, based on records averaged for 34 years, average annual total rainfall 65.74 inches; *B*, Rio Piedras, based on records averaged for 24 years, average annual total rainfall 71.4 inches; *C*, Rio Grande, based on records averaged for 22 years, average annual total rainfall 117.45 inches.

east, and southeast. However, on the west coast there is the phenomenon of almost daily afternoon rains, which is attributed to alternating land and sea breezes and the physical effect of an abrupt lifting by the range of mountains comparatively close to the coast.

The rainfall at Lares, as shown in figure 6, illustrates perhaps more impressively the effect of wind direction and velocity and topography, resulting in an expectation of a distinctly drier period in the middle of the wet season.

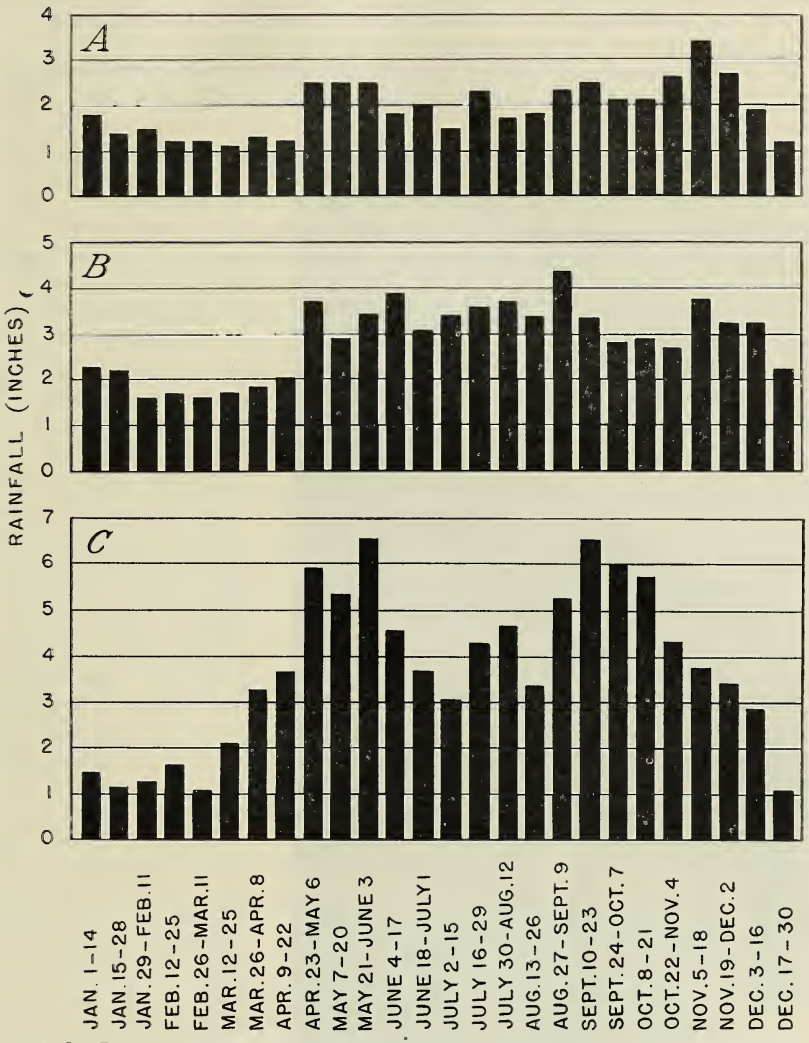

FIGURE 6.—Rainfall distribution at three rain-recording stations in Puerto Rico: *A*, Isabela, based on records averaged for 24 years, average annual total rainfall 50.1 inches; *B*, Bayamon, based on records averaged for 34 years, average annual total rainfall 75.16 inches; *C*, Lares, based on records averaged for 24 years, average annual total rainfall 96.53 inches.

Heavy rainfall can be made an asset.

Appreciation of the normal expectation of total rainfall and distribution, and an understanding of the optimum environment for some of the new crop plants now being tried in Puerto Rico, should

make assets of these different environments rather than obstacles to be surmounted.

Moreover, the comparatively heavy and well-distributed rainfall throughout the year at the higher elevations in Puerto Rico indicates potential hydroelectric power, which not only can be made of direct service to agriculture but also indirectly by reducing costs of industrializing or processing agricultural products.

In Japan almost all inland waters are utilized for producing fish and other fresh-water foods: this resource is still open to utilization in Puerto Rico.

SOIL EROSION CONTROL A BASIC RECONSTRUCTION PROBLEM

Erosion is depleting nutrients available to crop plants.

A large proportion of the soils of Puerto Rico are very heavy compact clays which, in comparison with the soils of the continental United States, seem to be comparatively resistant to erosion. Yet the heavy rainfalls as indicated to some extent in figures 3 to 6 and the tropical intensity of rains, of which there are as yet only limited records, coupled with the nature of the topography, have made soil erosion a very important factor in the agriculture of the island. The heavy, compact nature of the soils has resulted in much sheet erosion as well as gullying.

FIGURE 7.—Bare steep hillside in the mountainous region near Cidra, P. R., plowed and cultivated to corn and tobacco. The diagonal lines across the slope of the hill are windrows of dead vegetation, previously cleared from the field.

Many of the hillsides have completely lost their surface soil where improperly managed. As these surface soils usually contain the highest concentrations of nitrogen and other plant nutrients, plants are now being grown on comparatively unproductive surface soils produced from former subsoils.

Figures 7 to 10, indicate something of the steep slopes, irregular topography, and nature of erosion of fields which are being cultivated. Where general field crops, such as corn or tobacco, are grown on such hillsides, damage from soil erosion is likely to be very great in case of heavy rainfall.

Uncontrolled erosion impoverishes the farms and will nullify permanent reconstruction.

Examination often shows that the ridges of the hills consist of nothing but hard subsoils upon which vegetation of any nature has difficulty in maintaining itself. Even the areas devoted to coffee culture, in which the soils are seldom disturbed by cultivation, experience severe erosion losses. This is apparently a result of the steep slopes and frequent heavy rains of tropical intensity.

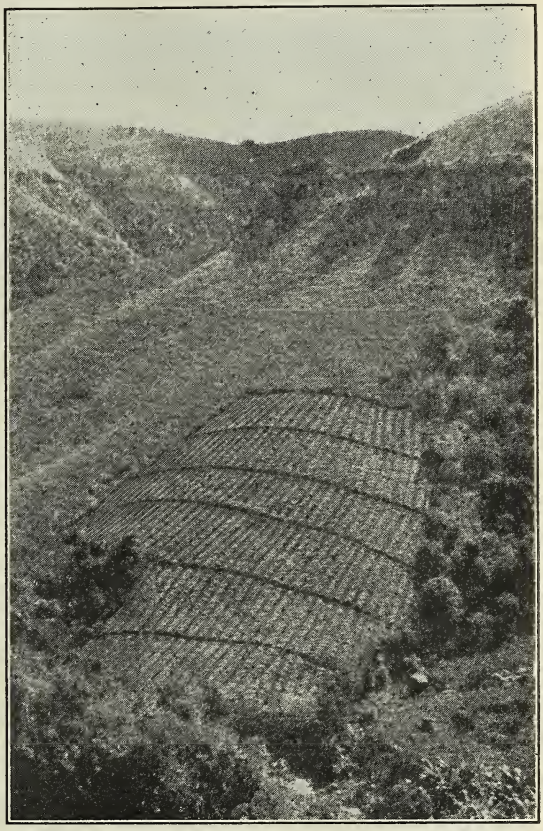

FIGURE 8.—Tobacco seedbeds located on a steep hillside near Comerío, P. R. The seedbeds are laid out parallel to the slope of the steep hillside and horizontal ditches are provided to intercept the run-off.

Many observations of cultivated fields such as those shown in figures 7 to 10 and the heavy suspension of mud in the rivers lead to the conclusion that studies of measures to check soil erosion must be undertaken, and that permanent reconstruction, based upon agriculture, is in turn dependent not only upon checking soil erosion but also upon a plan of restoration of plant nutrients to soils already badly depleted by erosion. The conclusion also seems apparent that accelerated soil erosion of agricultural land is largely brought about by using lands for purposes or in ways to which they are not naturally adapted; the control of such destructive erosion, therefore, logically results through redirecting the use of such erosive lands according to their potentialities.[1]

SWEET CORN FOR WINTER MARKETING

Field corn picked green is usual substitute for sweet corn in the Tropics.

One of the crops which would seem to meet the specifications for the Puerto Rican situation has resulted from corn-breeding experi-

[1] For valuable suggestions in preparing this brief review of the soil erosion problems of Puerto Rico, grateful acknowledgment is due H. G. Knight, Chief of the Bureau of Chemistry and Soils, and W. W. Pate and A. T. Holman, of the Soil Conservation Service, U. S. Department of Agriculture.

ments at this station during the past 14 years. To our knowledge sweet corn had never been produced in the Tropics previously. What is usually accepted as table corn in the Tropics is field corn picked

FIGURE 9.—Sheet erosion and start of gullying on hillside prepared for corn planting near Barranquitas, P. R. The black lines at right angles to the slope of the land represent windrows of dead vegetation inadequate to control erosion.

FIGURE 10.—Advanced stage of sheet erosion on an unprotected cornfield near Comerío, P. R. Stunted mature corn and visible erosion from top to bottom of the slope show the trend of Puerto Rican agriculture in many hilly and mountainous areas.

green. Sweet corn varieties of the continental United States are frequently brought to the Tropics but are clearly not adapted to the environment, making very poor growth. Perhaps the most impor-

tant limiting factor is their severe susceptibility to yellow-stripe disease of corn, a virus disease transmitted by an insect vector, *Peregrinus maidis*.

Development of sweet corn varieties adapted to Puerto Rico.

In 1922 Thomas Bregger, at that time plant breeder of the station, discovered several ears of field corn which contained a number of kernels having some typical sweet corn characteristics. These ears

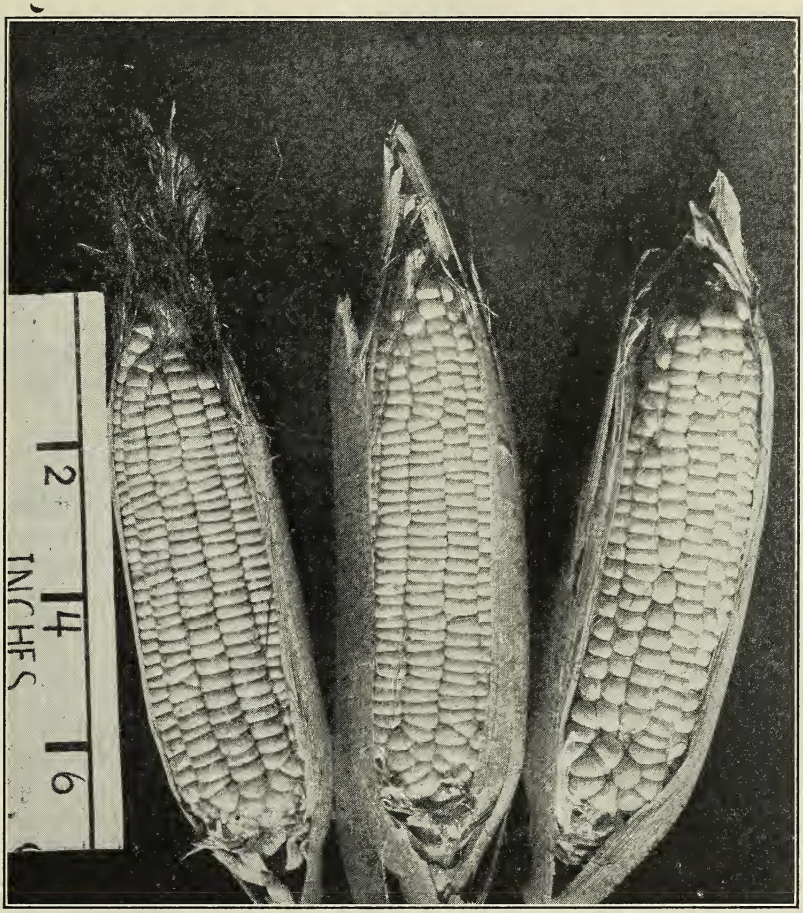

FIGURE 11.—Three ears of USDA–34, a tropical sweet corn variety developed by the selection of soft kernels from field corn and repeated backcrossing with field corn. The three ears were selected in the field and picked at random.

came from the farm of Irizarry Bros. in Lajas, P. R. Mr. Bregger shortly thereafter left the station and turned the work over to Robert L. Davis, agronomist, who has continued working with the idea of developing a tropical sweet corn. His various backcrosses between the new soft-kernel selections and Puerto Rican field corn have been referred to in previous annual reports of the station.

In the past year Mr. Davis has developed two sweet corn varieties as a culmination of the various backcrosses of these sweet corn selections with the original field corn. These varieties are USDA–32 and

USDA–34 [2] (fig. 11). Both are characterized by resistance to yellow-stripe disease and Stewart's disease of corn. Both meet with instantaneous approval by visitors from the North who sample them. USDA–34 in particular is characterized by long kernels, and large amount of corn per ear of especially good edible quality.

Successful shipment of sweet corn to New York in January.

In January 1935 an experimental shipment of the USDA varieties was made to New York in cooperation with A. S. Mason of the Bureau of Agricultural Economics of the United States Department of Agriculture. The corn was picked in the early morning, immediately placed in crates containing cracked ice, and transported to San Juan, where it was repacked, 75 ears to the crate, each crate also being re-iced. On the same day the corn was shipped to New York in cold storage at approximately 34° F. Handlers of such products in New York City were at first skeptical as to the commercial possibilities of the shipment, but their later statements indicated that the quality of the Puerto Rican product was equal to that of Golden Bantam corn grown in New Jersey and on Long Island, and superior to corn shipped in from far-distant points in the United States. The consignment sold in New York City for $4.50 per crate.

The results would seem to warrant continuation of studies not only to improve agronomic and shipping methods but to secure further improvement of the USDA varieties now available.

BAMBOO PROPAGATION AND UTILIZATION

Bamboo enters into all activities of life in far eastern countries.

Early in the fiscal year Gov. Blanton Winship called to the attention of the station the many and diverse ways in which bamboo is utilized in the East Indies, China, and Japan for household and farm purposes. He suggested that utilization of bamboo in similar extensive ways could be of great value to the agriculture of Puerto Rico, especially to the small farmers. The station, acting at once on the suggestion of the Governor, undertook a study of bamboo utilization; a survey was first made to determine the bamboo species already in Puerto Rico and their value, and species of recognized industrial value which might be introduced.

Bamboos are not indigenous to the West Indies.

There is a very generally planted bamboo species in Puerto Rico which is commonly but erroneously called native bamboo. The species is *Bambusa vulgaris*, which apparently was introduced some hundred or more years ago, possibly by the Spanish padres who are known to have been interested in plant propagation and introductions.

Shop work was undertaken by the station with material of *B. vulgaris*, but it was found to be so soft as to have little value for furniture manufacture or farm use. Moreover, it was found to be attacked by a borer, commonly but mistakenly accepted as a termite. Shop work on this species was, therefore, given little attention, and utilization studies have been directed toward other bamboo species apparently more valuable for industrial uses.

[2] USDA stands for U. S. Department of Agriculture.

Bamboo species have been introduced by the station.

In past years 10 bamboo species had been introduced by the station as follows: *Dendrocalamus latiflorus*, *D. strictus*, *D. giganteus*, *Bambusa arundinacea*, *B. tulda*, *B. balcooa*, *Cephalostachyum pergracile*, *Bambusa* sp. ("Buddha's belly"), *Phyllostachys* sp., *B. thouarsii*. *B. thouarsii* is possibly identical with *B. vulgaris*.

Studies were immediately undertaken to determine the values of these different species for household and farm purposes.

Stalks of bamboo species resistant to the borer.

One of the bamboos, *Dendrocalamus strictus*, was found frequently to be solid, or in those cases where a central cavity occurred, the hollow portion was usually very small. Stalks of this species were found very useful for various types of furniture. It was found to be highly resistant to the borer.

Another species, *B. tulda*, having very long joints, strong and with fine grain, was found to be desirable for the manufacture of furniture; strips of this bamboo made beautiful panels and flat surfaces. A 30-foot ladder was made of stalks of this species. This species was also found to be highly resistant to borers.

B. arundinacea was found to have canes with thick walls, the outer parts of the walls being resistant to borers. It is one of the largest species studied and served admirably for farm purposes such as the construction of small footbridges, fences, and hayracks. It is a spiny species and when planted in hedges is impenetrable.

A fourth introduced species, *D. giganteus*, belies its name for it is not gigantic, being exceeded in size by *B. arundinacea*, *B. vulgaris*, and *B. tulda*. However, in shop work it was found to have a smooth grain and to be capable of taking a beautiful polish. The fiber is relatively resistant to borers.

Rapid propagation of new industrial species was essential.

The shop work was immediately successful and appeared to interest all visiting agriculturists. Inasmuch as the quantities of these better bamboos were inadequate for extensive industrial use, a program for their rapid propagation was undertaken at once. The Federal Emergency Relief Administration quickly appreciated the value of the utilization of bamboos for farm and home use, and has furnished labor not only for the shop work but also field men to advance the propagation of the more valuable species as rapidly as possible.

Table 3 shows the increase in the numbers of plants of the bamboo species June 30, 1935:

TABLE 3.—*Bamboo species being propagated, the numbers of clumps originally available, and the numbers of small plants available for distribution on June 30, 1935*

Species	Clumps available for propagation	New plants available for distribution
	Number	*Number*
Dendrocalamus giganteus	5	5
Dendrocalamus strictus	62	230
Bambusa arundinacea	1	714
Bambusa tulda	10	259
Bambusa balcooa	1	200
Cephalostachyum pergracile	1	30
Bambusa sp. ("Buddha's belly")	2	40
Total		1,478

Additional bamboo species were introduced.

The Emergency Relief Administration also cooperated in sending one of our personnel, Armando Arroyo, to the mainland to study bamboo propagation and utilization there. On returning to Puerto Rico, Mr. Arroyo brought with him, from the Bureau of Plant Industry, plants of the following species: *Guadua angustifolia*, *Dendrocalamus latiflorus*, *D. membranaceus*, *Gigantochloa verticillata*, *Bambusa pallescens*, *B. longispiculata*, *B. tulda*, *B. multiplex* var. *argentea striata*, *B. multiplex* var. Alphonse Karri, *B. multiplex* var. *disticha* (plain), *B. multiplex* var. *disticha* (striped), *Oxytenanthera abyssinica*, *Shibataea kumasasa*, and Fan Taan bamboo. These introductions arrived in May and all seem to have established themselves.

FIGURE 12.—Some of the first articles made from bamboo at the experiment station. The chair, sewing table, and serving tray to the right were fabricated from *Dendrocalamus strictus* and *Bambusa tulda*. The table and curtain rod at the left were manufactured from *B. vulgaris*. These articles could serve for everyday usage in the house of the small farmer and would greatly improve his standard of living.

The common bamboo borer is not a termite.

It was found that the common borer which does so much damage to the soft bamboo species is not a termite as the Spanish term "polilla" might be taken to indicate, but is a powder-post beetle, *Dinoderus minutus*, belonging to the family Bostrychidae. During the year some degree of success was obtained in inhibiting the entry of this beetle even into the soft bamboos by the use of shellac containing insect poison or deterrents. Studies are being continued in search of a solvent for the ordinary polishing waxes which will also be a solvent for an effective insecticide or insect deterrent.

Many uses for bamboo have been developed.

During the year there were manufactured experimentally the following articles for farm households: Picture frames, curtain rods, chairs, tables, sewing tables, wastebaskets, table lamps, floor lamps, bookcases, suitcase benches, serving trays, porch chairs, children's toys of several kinds, tobacco humidors, cigarette holders, cigar

holders, penholders, a fountain pen, ladies' fans, wall vases for flowers, rulers, ash trays, walking sticks, and paper cutters. Figures 12 to 15 show the nature of some of the articles manufactured from bamboo.

For farm use there were constructed bridges, ladders, stepladders, fences, hayracks, flowerpots, garden sticks, and poultry runs. The conclusion reached is that a number of the introduced bamboo species lend themselves perfectly to farm use; not only will these bamboo species enable the small farmer to furnish his house more adequately and to conduct his farm operations more cheaply, but also there seem to be possibilities for the fabrication of articles for export.

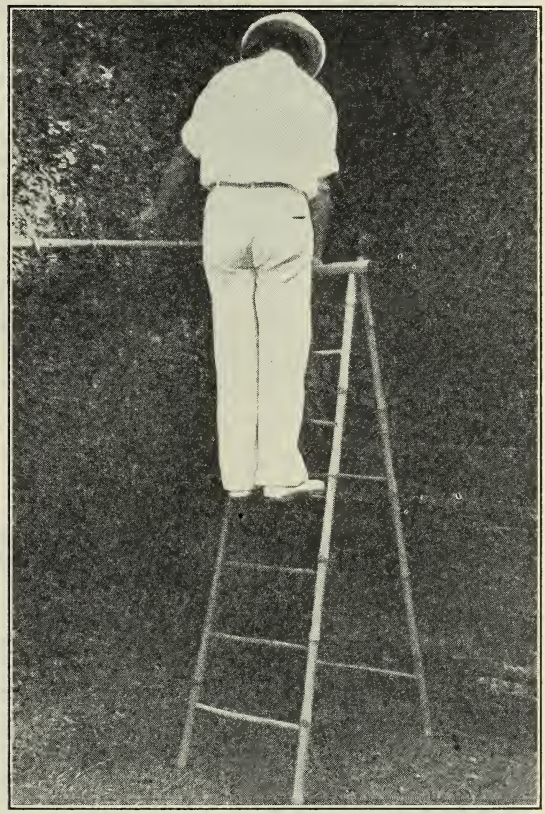

FIGURE 13.—A stepladder fabricated from stalks of *Dendrocalamus strictus*. The man on the stepladder weighs 196 pounds.

Bamboos are resistant to hurricanes and check erosion.

Bamboos in general are among the most resistant of tropical plants to hurricanes, and used with discretion constitute the best possible windbreaks. Nearly all bamboo species also produce tremendous masses of roots which form excellent protection against soil erosion and aid in preserving river banks. Some of these species constitute perhaps the most valuable introductions of economic plants which have been made into Puerto Rico.

COFFEE RESEARCH CENTER ORGANIZED

Coffee growers one of the largest groups of small farmers in Puerto Rico.

At the beginning of the year it was apparent that the coffee planters needed the greatest possible aid in research leading to lessened costs and increased production per acre in order that they might compete more successfully with the coffee-producing regions of other countries where land and labor costs are much lower, the hurricane liability is much less, and production per acre is higher. It was agreed that the station at Mayaguez was best prepared to

serve the coffee-growing areas of Puerto Rico. A cooperative arrangement was therefore agreed upon by the college of agriculture

FIGURE 14.—The picture frame in the illustration was fabricated from *Bambusa tulda*; it is laminated and contains cross wedges at the corners with an attached bamboo easel at its back. In the foreground are a fan, water dipper, goblets, serving tray, and bamboo tube used as a container for the fan. These were fabricated from *Dendrocalamus strictus* and *B. tulda*.

FIGURE 15.—Table, desk lamp, penholders, humidor, chair, wastebasket, picture frame, and bookcase manufactured from bamboo of the species *Dendrocalamus strictus* and *Bambusa tulda*.

and the experiment station of the University of Puerto Rico, the Puerto Rico Department of Agriculture and Commerce, and the

station of the U. S. Department of Agriculture whereby investigational work in the coffee industry would be centered at the Federal station in Mayaguez. The experiment station of the University of Puerto Rico has assigned its coffee agronomist, Jaime Guiscafré Arrillaga, to cooperative work at the Federal station; the College of Agriculture and Mechanic Arts has from time to time sent one or several of its staff on field trips in coffee investigations with representatives of the Federal station; the Department of Agriculture and Commerce has frequently contributed the services of Carlos A. Figueroa, marketing specialist, for coffee studies; the Federal station has furnished laboratory space, orchard and field areas, field equipment, and some of its personnel; these joint efforts in coffee investigations have resulted in what is called the coffee research center located at the Federal experiment station at Mayaguez.

Excess of shading diminishes coffee yields.

Tests of the effect of different degrees of shading upon yields of *Coffea arabica*, Puerto Rican variety, were completed in December 1934. In this experiment eight coffee trees were grown from the time of planting without benefit of any shade; eight coffee plants of clons identical to those grown without shade were planted in a lath house in which one-half of the sunlight was excluded; eight additional trees of identical clons were planted in a lath house in which two-thirds of the normally occurring sunlight was excluded.

There were no replications of these plats due to the high cost of the lath house, but the plantings were contiguous, and the soil of the unshaded plants was mixed with the soil of the plants receiving one-half sunlight and one-third sunlight. All trees were planted in August 1931. The 1933 crop was the first harvested. A tabulation of the yields harvested in the 1933 and 1934 crops is shown in table 4.

TABLE 4.—*Average yields per tree for the 1933 and 1934 crops from coffee trees receiving total normally occurring light without shade as compared with trees receiving one-half light and trees receiving one-third light* [1]

Treatment	Average yield per tree [2]	
	1933 crop	1934 crop
	Ounces	*Ounces*
Trees grown with ⅓ normal light admitted	3.7	25
Trees grown with ½ normal light admitted	9.9	48
Trees in unshaded normal light	3.7	96

[1] The experiment was planned by T. B. McClelland and the 1933 crop was harvested by him; the 1934 crop was harvested by Carlos Esteva, Jr., the first coffee agronomist of the experiment station, University of Puerto Rico, assigned to the coffee research center.

[2] Fresh weight.

Table 4 shows that when the trees were younger the half shade improved the yields as compared with the heavier shade or no shade. However, in the second crop, with the trees older and larger, it is evident that the unshaded trees far outyielded either those receiving half shade or two-thirds shade.

This year the trees grown in full sunlight averaged 6 pounds of fresh coffee berries per tree. The trees grown under the lath house in which the light was diminished by 50 percent averaged 3 pounds

per tree. The trees grown in shade in which two-thirds of the light was excluded by the lath yielded 1 pound 9 ounces per tree.

The conclusion which one might hastily reach would be that *Coffea arabica* should be grown without shade in Puerto Rico. However, the trees grown without shade, although yielding much more prolifically than the trees with one-half and two-thirds shade, are obviously in bad physiological condition and would not be expected to have the length of life of shaded trees. The conclusion which would seem evident from the data, together with the general condition of the trees in the experiment at the present time, is that one-half exclusion of sunlight unfavorably affects yields of coffee berries. Full sunlight, although greatly increasing the yields, unfavorably affects the health of the trees. It now seems that some shading is desirable, but much less than that which would exclude one-half of the normally occurring light.

Identical berry yields of Columnaris and Puerto Rican varieties of Arabian coffee.

In 1931 an experiment was undertaken at the station in which the yields of trees of the Columnaris variety of Arabian coffee were to be compared with the yields of the commonly grown Puerto Rican variety of *Coffea arabica*. Seven replications of the trees of each variety were planted, each replication consisting of one line of trees with from six to nine trees to each row.

In February 1935 the crop from this experiment had been completely harvested, and the results are shown in table 5.

TABLE 5.—*Yields of fresh coffee berries per tree of the Columnaris compared with the Puerto Rican, both varieties of Coffea arabica*[1]

Variety	Trees	Total weight of berries	Average yield per tree
	Number	*Kilograms*	*Kilograms*
Columnaris	50	61.696	1.234
Puerto Rican	50	61.540	1.231

[1] This experiment was planned by T. B. McClelland and the crop was harvested by Carlos Esteva, Jr.

It is obvious from these figures that there was no significant difference between the yields of the two varieties.

The Columnaris variety originated in Java and was introduced from there by T. B. McClelland.

Columnaris variety of Arabian coffee resistant to root rot.

There are two types of root rot on Arabian coffee in western Puerto Rico. One of these is called white root rot and is apparently caused by a fungus of which the identity is unknown; the second, black root rot, is caused by the fungus *Rosellinia bunodes*. Rafael A. Toro, of the College of Agriculture and Mechanic Arts, University of Puerto Rico, in some of his field studies of coffee observed the Columnaris variety of known identity interplanted with the Puerto Rican variety, but found no cases of either of these root rots attacking Columnaris, in situations in which the Arabian coffee of Puerto Rican variety was severely affected. He, therefore, tenta-

tively concluded that the Columnaris variety is more resistant to these root rots than the Puerto Rican.

Columnaris is considerably taller, the leaves are slightly larger, and the trees have a more robust appearance in this experiment than the trees of the Puerto Rican variety. It would seem that Columnaris should be kept under further observation.

ANIMAL PARASITOLOGY

Lice of domestic animals are less common and serious in Puerto Rico than in the continental United States.

Studies made by H. L. Van Volkenberg, parasitologist, during the year have increased the knowledge of the lice infesting domestic animals, including birds, and it is now possible to compare species found in Puerto Rico with those occurring in the continental United States. Such a comparison is shown in table 6.

TABLE 6.—*Species of lice found in the continental United States and in Puerto Rico*

Host	Most common species of lice in the United States	Species of lice found in Puerto Rico
Horse	*Haematopinus asini* *Trichodectes pilosus* *Trichodectes parumpilosus*	Apparently no species affecting horses.
Cattle	*Haematopinus eurysternus* [1] *Linognathus vituli* *Solenopotes capillatus* *Trichodectes scalaris*	*Haematopinus tuberculatus.*
Swine	*Haematopinus adventicius*	*Haematopinus adventicius.*
Goat	*Linognathus stenopsis* *Trichodectes climax* *Trichodectes hermsi*	*Linognathus africanus.* *Bovicola caprae.*
Dog	*Linognathus piliferus* *Trichodectes latus*	*Heterodoxus longitarsus.* [2]
Cat	*Felicola subrostrata*	*Felicola subrostrata.*
Chicken	*Eomenacanthus stramineus* *Menopon gallinae* *Lipeurus caponis* *Goniocotes hologaster* *Goniodes dissimilis* *Lipeurus heterographus* *Goniocotes gigas*	*Eomenacanthus stramineus.* *Menopon gallinae.* *Lipeurus caponis.* *Goniocotes hologaster.* *Goniodes dissimilis.* *Menacanthus* sp.
Turkey	*Eomenacanthus stramineus* *Goniodes meleagridis* *Lipeurus gallipavonis*	*Eomenacanthus stramineus.* *Goniodes meleagridis.* *Lipeurus gallipavonis.* *Colpocephalum* sp.

[1] *Haematopinus eurysternus* has been collected in Puerto Rico but apparently is not established.
[2] *Heterodoxus longitarsus* is established in the United States.

As indicated in table 6, the number of species of lice found on animals other than birds in Puerto Rico is somewhat restricted. Among these species the only common forms are a biting and a sucking louse on the goat and a sucking louse on cattle. This cattle louse is similar in size to the hog louse, but as the adult lice are localized in the long hairs at the end of the tail its numbers on each animal are limited, and it does not cause as much damage as some of the other lice which may spread over a large portion of the body.

The body louse, *Eomenacanthus stramineus*, of the chicken seems to be as abundant in Puerto Rico as in the continental United States.

The head louse, *Lipeurus heterographus*, common and serious on the continent, has not been found on Puerto Rican fowls.

It is known that other species of lice have been introduced into Puerto Rico but apparently they have not been able to establish themselves. The scarcity of enzootic species of lice raises the question of possible beneficial biological relationships brought about by climatic factors such as temperatures, intensity and duration of sunlight, and comparative continuance of moist conditions. The distribution of parasitic species is naturally dependent also upon the kinds and numbers of introduced host animals, and it is true that there have been few importations of animals into Puerto Rico from other tropical regions. Considerable is known in regard to the lice in the temperate regions, but very little study has been made of the species and their distribution in the American Tropics. Comparing Puerto Rico and the continent, the lice seem to show as much, or more, geographical variation in distribution as any other related group of parasites found on animals.

Parasitic mites are less important economically in Puerto Rico than in continental United States.

Dr. Van Volkenberg has been able to summarize the knowledge of the occurrence and importance of the species of parasitic mites found on animals in Puerto Rico, and to compare them with the species occurring in the United States. In table 7 the species are arranged according to their importance, with the exception of the mites of the dog and the chicken, the most common being placed first in the list for each host.

TABLE 7.—*Species of parasitic mites found in the continental United States and Puerto Rico*

Host	Species of mites found in the United States	Species of mites found in Puerto Rico
Horse	*Sarcoptes scabiei equi* *Psoroptes equi* *Chorioptes equi*	*Psoroptes equi.* *Sarcoptes scabiei equi.*
Cattle	*Psoroptes bovis* *Chorioptes bovis*	*Psoroptes bovis.*
Swine	*Sarcoptes scabiei suis* *Demodex phylloides*	*Demodex phylloides.* *Sarcoptes scabiei suis.*
Dog	*Sarcoptes scabiei canis* *Demodex canis* *Otodectes cynotis*	*Sarcoptes scabiei canis.* *Demodex canis.* *Otodectes cynotis.*
Cat	*Notoedres cati*	*Notoedres cati.*
Chicken	*Dermanyssus gallinae* *Cnemidocoptes mutans* *Cnemidocoptes gallinae* *Laminosioptes cysticola* *Cytoleichus nudus* *Liponyssus sylviarum* *Rivoltasia bifurcata* *Megninia cubitalis* *Trombicula irritans* (larva)	*Liponyssus bursa.* *Cnemidocoptes mutans.* *Cytoleichus nudus.* *Megninia cubitalis.* *Epidermoptes* sp. *Trombicula tropica* (larva).

Like the lice, the parasitic mites are considerably influenced in their distribution and prevalence by climatic factors. It is known that the close confinement of animals during a cold season is favorable for the propagation and spread of lice and mange. Thus animals in a tropical climate have an advantage in that it is not necessary to confine them in warm, enclosed stables at any season.

It is also to be noted that fewer species of mites are recorded in Puerto Rico than in the continental United States. Mites in general seem to be of less economic importance here than on the continent.

Several new pathogenic protozoa of domestic animals found.

During the past year Dr. Van Volkenberg has added more data to the information already accumulated in regard to the protozoan diseases, and several pathogenic protozoa are herein reported in Puerto Rico for the first time.

Among the protozoa, the coccidia are most frequently encountered. Although these organisms are commonly found in the intestinal tract of cattle, swine, goats, dogs, and cats, acute coccidiosis seems to be a rare disease in these animals. However, in calves coccidia may produce a more or less chronic condition with loss of weight or lack of growth. Examinations of unthrifty calves which were carefully fed and were comparatively free of intestinal worms have shown large numbers of coccidia in the feces. The condition of the animals improved as soon as the coccidia disappeared or decreased in numbers. There was a diminished appetite and the feces were softer than normal, although there was no pronounced diarrhea. In old work oxen or those that are subject to heavy work, diarrhea often occurs, with a gradual loss in strength and weight. Coccidia are often abundant in the feces of such animals.

Intestinal disorders are causing losses and interfering with growth and development especially of pigs and young hogs in Puerto Rico. Among the parasites associated with such disorders are several kinds of worms and protozoa. Among the protozoa, coccidia are most often found.

Coccidia are also common in the goat. The species *Coccidia faurei* is found in masses as small whitish patches on the wall of the small intestine. Among goats slaughtered for meat purposes these patches are often found in intestines which otherwise appear to be normal. Nothing is known in regard to the pathogenicity, if any, of this organism in goats.

Several diseases limit Puerto Rican poultry production.

Among poultry the parasitic species *Eimeria tenella* produces here and elsewhere a serious and often fatal disease in chicks. Coccidiosis and chickenpox seem to be the greatest obstacles to be overcome in successfully raising chickens in Puerto Rico.

Enterohepatitis, or blackhead of turkeys and chickens, caused by the protozoan species *Histomonas meleagridis*, occurs in Puerto Rico. Aside from encountering the organisms and associated lesions, very little is known in regard to the disease although it has caused many persons to abandon entirely attempts to raise turkeys and chickens. Turkeys seem to thrive best in the drier areas of the island and it is possible that this disease is a limiting factor in the wet areas.

Piroplasmosis of dogs, a disease caused by a protozoan related to the organism that causes tick fever in cattle, has been found. The brown dog tick, *Rhipicephalus sanguineus*, which is very common and widely distributed, is probably the only vector of the disease in Puerto Rico. So far only the chronic form of this disease has been encountered.

Anaplasmosis in cattle was unusually common during February and March and the disease seemed to be very severe. Several valu-

able cows in Mayaguez and vicinity succumbed to the disease. Since 1929 over 100 positive cases of this disease have been encountered at Mayaguez. The last positive case of piroplasmosis occurred in February 1931 in a cow recently imported from Virginia, and resulted fatally. Apparently the native and acclimated cattle are highly immune to piroplasmosis, while the immunity to anaplasmosis is only partial. One cow is known to have had three acute attacks of anaplasmosis and several have had the disease at least twice. Often animals on recovering from anaplasmosis develop a depraved appetite and unless prevented will eat soil and filth. This condition is so characteristic that it has been described as a separate disorder or disease.

MANUFACTURE OF TABLE SIRUPS FROM SUGARCANE

Blending of several varieties gives best flavor.

During the year J. O. Carrero, assistant chemist, was able to continue and bring to a conclusion his studies of the manufacture of table sirups from sugarcane juices. The studies were opportune in view of some surplus of sugarcane which was not milled as a result of the marketing arrangements under the Jones-Costigan Act.

It was found that juices of the varieties P. R. 803, F. C. 916, B. H. 10/12, and M. 28 clarified with the greatest ease and yielded sirups of the lightest color and greatest brilliance. The best flavor was obtained when the juices of several varieties were blended and, especially, blending the juices of variety B. H. 10/12 seemed to improve the flavor of the sirup. In the clarification of the juices heating and filtering with refined diatomaceous earths resulted in filtration with the greatest ease and maximum rate of flow, and gave sirups of the greatest clearness and brilliance.

Crystallization was best prevented by the addition of invertase.

To prevent crystallization, inversion of the sucrose by either yeast or invertase affected the flavor least. The use of yeast seemed most advantageous when employed in the juice, while invertase seemed to be used most advantageously on sirups of 30° to 45° Brix. Moreover, inversion by yeast did not seem to go above a certain concentration of the resulting monosaccharides. The invertase, however, seems capable of inverting sugar at almost any concentration of the invert sugars and is susceptible of better chemical control.

A number of small manufacturers of table sirup have consulted the station about these practices, and considerable service appears to have been rendered them.

DISTRIBUTION OF ECONOMIC AND ORNAMENTAL PLANTS

The station has large collection of tropical plants.

N. L. Britton, former director of the New York Botanical Garden, is credited as saying that the experiment station at Mayaguez has the largest collection of tropical plants in the Western Hemisphere and the best recorded. It is evident indeed that one of the most valuable activities of the station has been the introduction of many valuable economic and ornamental plants.

One measure of the value of these plant introductions perhaps would be the demand of the public for them. This demand is shown

by the records of the distribution throughout Puerto Rico of the progeny of such plants. Table 8 gives a record of the plant distributions of the station during the year 1934–35.

TABLE 8.—*Distribution of economic and ornamental plants during 1934–35*

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Apr.	May	June	Total [1]
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Sugarcane cuttings, M. 28	7,060	------	5,700	2,500	------	------	------	------	------	------	15,200
Guatemala grass cuttings	1,000	------	6,650	------	------	------	------	------	------	------	7,650
Sweet corn seed (ounces)	------	------	200	------	------	230	------	------	------	------	430
Coffee varieties	------	50	756	100	------	100	------	------	------	10	1,016
Bamboo (industrial)	------	16	17	------	------	------	------	------	------	------	33
Avocadoes	------	------	------	------	------	------	------	2	4	------	6
Papayas	------	------	50	------	------	------	------	------	------	------	50
Citrus trees	12	------	10	204	------	------	------	------	22	14	262
Mango varieties	17	3	43	7	5	------	4	3	6	2	90
Mangosteen trees	------	------	------	------	------	------	------	1	2	------	3
Hibiscus cuttings	483	444	731	767	432	------	------	1,604	4,060	------	8,521
Hibiscus plants	------	------	------	------	------	9	1,431	------	------	270	1,710
Java grass sod	[2] 1	------	------	------	------	------	------	------	------	------	[1] 1
Palms	35	99	575	44	20	81	50	31	44	29	1,008
Violet trees [3]	8	8	2	2	------	2	3	2	------	------	27
Bougainvillea varieties	36	45	59	190	34	22	42	------	26	534	988
Cashew nut	------	------	100	------	------	------	------	------	------	------	100
Waterlillies	2	11	------	------	------	------	------	10	4	------	27
Miscellaneous economic plants	30	12	230	149	5	28	25	12	60	278	829
Miscellaneous ornamental plants	56	344	252	301	117	517	348	259	763	294	3,251
Ornamental vines	14	4	14	89	6	11	26	124	38	15	341
Total	8,694	1,036	15,389	4,353	619	1,000	1,929	2,048	5,029	1,446	41,543

[1] Records were not as yet undertaken in July and were not reported for March.
[2] 1 truck load.
[3] *Phlebotaenia cowellii.*

The table shows that a total of 41,543 plants and cuttings were distributed without charge during the year. The most numerous of these plant distributions consisted of cuttings of sugarcane varieties of peculiar value to certain types of cane lands. The next largest item in the plant distribution was *Hibiscus* varieties. It is the intention of Governor Winship to beautify Puerto Rico and encourage the tourist industry. The demand for *Hibiscus* has been to a considerable degree due to this campaign to beautify the island.

The third item in distribution consisted of cuttings of Guatemala grass, a service to the dairy industry of Puerto Rico.

It is of interest to note that the station distributed an average of 4,154 plants and cuttings per month, a service which has been carried on for years.

SEVERAL INTRODUCED PLANTS SHOW ECONOMIC IMPORTANCE

The mangosteen thrives in western Puerto Rico.

In 1903 two small mangosteen trees, *Garcinia mangostana*, were introduced from Trinidad by O. W. Barrett, at that time entomologist of the station. *G. mangostana* is an East Indian species of somewhat limited distribution. The two trees have thrived in the moist humid climate and heavy clay soils of western Puerto Rico, and seem perfectly adapted to the environment of the area in which coffee is now the principal crop. For the past several years these two trees have produced large crops of fruit, and all visitors from the continent are very favorably impressed with their flavor and

character. The fruit with its hard thick rind is apparently resistant to the West Indian fruit fly. It also has very good keeping and shipping qualities, having been kept in refrigeration at the station for several weeks at a time. During the year approximately 150 seedling trees were started from fruits from these two mature trees at the station, and work has also been undertaken to propagate additional trees by marcotage.

It is very evident, particularly when the trees are young, that they must be shaded as in the case of certain of the coffee species.

During the year, a minor disorder developed in the mature trees, diagnosed as identical with the thread blight of coffee caused by the fungus *Corticium koleroga.*

Travelers to the East Indies have given the mangosteen such favorable notice, and it appeals to visitors so readily and favorably that it would seem to be a crop which should be pushed as rapidly as possible for planting in the moist coffee areas of Puerto Rico, where new and more profitable crops are an urgent necessity.

Palm chestnuts thrive in Puerto Rico.

In March 1922, 2 pounds of seed of *Guilielma utilis* were received from the Bureau of Plant Industry of the United States Department of Agriculture. In Honduras and Guatemala the seed of this palm is used as a food material, having a taste somewhat similar to chestnuts. It is known there as the pejibaye palm, but since this word has no significance here, it has been called the palm chestnut.

It is evident that the trees are well adapted to th. wet environment of western Puerto Rico and are not attacked by insects or diseases. During the year one of the trees fruited prolifically, and the fruits when harvested were steamed in salt water as is done with chestnuts. All who tasted them were very favorably impressed and noted their characteristic chestnut flavor and excellent texture. They have the color of a yellow turnip with flesh perhaps somewhat firmer than that of a turnip. The fruits are considerably larger than an ordinary chestnut and their food value, as shown in table 9, is considerable.

TABLE 9.—*Chemical composition of 3 fruit samples of castaña de palma, Guilielma utilis* [1]

Condition of material	Moisture	Dry matter	Ether extract	Protein	Sugar	Starch
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Fresh	61.41	39.48	5.00	1.56	(2)	22.71
Dry basis	0	100.00	12.66	3.95	(2)	57.49

[1] Analyses and calculations by J. O. Carrero. [2] Trace.

The trees grow well on hillsides which under ordinary conditions in Puerto Rico would be considered waste land. The production of these nuts is worthy of attention as a means of utilization of some of the waste land and of easily and cheaply providing a slight increase in the food supply.

The trees are propagated easily from shoots which grow at the base of the mature trees, and during the year measures were taken to increase the numbers of available trees, at present not more than a half dozen in number.

Uvaria lancifolia does well in western Puerto Rico.

Uvaria lancifolia is one of the Annonaceae which came into abundant fruiting during the year. Seeds of this species were received from P. J. Wester from the Philippines in 1929. The species bears handsome red fruits against a dark-green foliage and gives a pleasing ornamental effect. The fruits are borne very prolifically on all of the five mature trees at the station. Individual fruits are approximately the size of a small plum and of pleasing flavor to all who have tasted them. The fruit is hardly one which will enter into the channels of commerce, but is a pleasing fruit for children and as one experimenter said, is "a fine fruit for small boys to steal."

The wax flower Phaeomeria speciosa is also well adapted to western Puerto Rico.

In 1927 seeds of *Phaeomeria speciosa*, the wax flower, were sent to the station from the Philippine Islands by H. T. Edwards, of the Bureau of Plant Industry, United States Department of Agriculture. It is an ornamental of the Zingiberaceae, with large spectacular pink flowers of a waxlike character. The plant apparently is perfectly adapted to the humid atmosphere and heavy soils of western Puerto Rico.

It was noted that the flowers had unusual keeping quality, sometimes persisting as cut flowers in water for 10 to 14 days. Multiplication of the species has been undertaken, and it has been distributed in considerable quantities during the year.

SERVICE TO ANIMAL INDUSTRY

Dairy animals in Puerto Rico show evidence of influence of bull importations.

The station maintains two carefully selected registered Guernsey bulls imported from the mainland United States for service to the dairy cows in the vicinity of Mayaguez. During the year, 151 cows were served by these Guernsey bulls.

This service to the dairy farmers of western Puerto Rico has been continued by the station for 30 years. Its influence is quite apparent in the character of the dairy animals observed throughout the farming sections of western Puerto Rico.

During the year, 2,196 dairy animals were dipped in the deticking vat of the station.

Dr. Van Volkenberg has received many calls and responded to requests for diagnoses for many sick domestic animals. This service is of great value to the small farmers in this somewhat isolated area where there is an inadequate number of veterinarians.

CORRELATING WORK OF AGRICULTURAL AGENCIES

Correlating committee prevents duplication or omission of agricultural projects.

One of the most important and fundamental advances in administration during the year was the organization of a "correlating committee" consisting of a representative from each of the Government institutions in Puerto Rico engaged in agricultural research, extension, education, or administration, to correlate the programs of such agencies. The organization of such a committee was dis-

cussed for several months by the heads of these agricultural institutions, among whom there was complete agreement that such correlation was essential. In November 1934 the chancellor of the university, Carlos A. Chardon, recommended to the trustees of the university appointment of members of such a committee, which was unanimously approved. Dr. Chardon then appointed as representatives from the university H. G. Parkinson, dean of the college of agriculture, M. F. Barrus, director of agricultural extension, and Francisco López Domínguez, director of the university experiment station. The Commission of Agriculture and Commerce, Rafael Menendez Ramos, represented his department, and the director represented the Federal experiment station. Professor Parkinson was elected chairman of the committee.

Service on the committee is, of course, voluntary. During the year the committee met six times. It is a pleasure at this time to express appreciation for sincere and effective cooperation of the members of the committee.

Correlation of research and extension programs.

The agricultural extension work has been correlated with the known research results in Puerto Rico. Close and friendly cooperation has been developed between the Federal station and the college of agriculture, the experiment station, and the extension service of the university; and the Department of Agriculture and Commerce of the insular government. The research program of the Federal station has been correlated with the research program of the university experiment station; duplication of efforts has been eliminated, and research projects have been allotted to either agency in accordance with advantages of location. personnel, or equipment available for each project.

The sugar industry research is undertaken jointly, with field studies allocated by a subcommittee. Allocations are based chiefly upon geographic position lending itself to economy of time and travel.

CORDIAL RELATIONSHIPS CONTRIBUTE TO SUCCESS OF THE EXPERIMENT STATION

Experimental farm a gift from the people of Puerto Rico.

In 1902 the Legislature of Puerto Rico appropriated $15,000 for the purchase of land for the Puerto Rico Experiment Station of the United States Department of Agriculture. Soils experts of the Department of Agriculture selected Mayaguez as the most appropriate site for the station, and when it was found that the cost of the most suitable farm in Mayaguez exceeded by $4,000 the amount appropriated by the legislature, the city of Mayaguez itself appropriated the additional amount of money for the purchase of the land. The people of Puerto Rico then ceded to the United States Department of Agriculture this farm of 235 acres, then known as Hacienda Carmen, immediately contiguous to the city of Mayaguez on the north. The transfer of the property states that it is the property of the United States Department of Agriculture as long as an experiment station is maintained on the land.

In 1910 the executive council of the government of Puerto Rico transferred to the station from the public lands 200 acres of upland

volcanic soils at Las Mesas 3 miles to the east of the city of Mayaguez. It should be appreciated then that the people of Puerto Rico and the people of Mayaguez at the inception of the experiment station extended the most cordial cooperation possible, and it is a pleasure to state that the same atmosphere of cordial cooperation exists at the present time.

Federal appropriations for the experiment station.

On its part the Federal Government in the 35 years from 1900 to June 30, 1935, has allotted $1,462,880 to the station for its operation. The income of the station for the year ended June 30, 1935, derived from Federal sources was $37,548.

RECENT DEVELOPMENTS OF THE STATION

Bamboo utilization project aided by emergency relief funds.

In January 1935 the Puerto Rico Emergency Relief Administration appropriated $500 per month for 6 months to aid in investigation by the station of the utilization of bamboos for farm and industrial use and for the rapid propagation of the best industrial bamboos. This work with the relief administration has been an outstanding success and has been marked by an unusual spirit of cooperation.[3]

Civilian Conservation Corps reforested 40 acres at Las Mesas.

In February 1935 the Civilian Conservation Corps placed 50 men on the reforestation and improvement work at the Las Mesas property of the station. This property consists of 200 acres of steeply sloping land, mostly so barren of vegetation as to have little value even for grazing. The declivities are so steep as to make access to the lower areas of the property very expensive in time and energy. With the help of the Civilian Conservation Corps a switch-back road, capable of being used by ox carts, was first constructed to reach the lower areas of the property; subsequently several ledges of good serpentine were found on the property and quarries developed and it was possible to surface the roadway cheaply with crushed rock from these quarries. The road to the lower areas of the property will now permit the safe passage of automobiles even in the wettest weather.

Utilizing this new roadway for hauling materials the Civilian Conservation Corps then planted approximately 40 acres of this barren, unproductive hillside with forest trees, 4,000 of the trees being West Indian mahogany (*Swietenia mahagoni*) and 4,000 rosewood trees (*Dalbergia sissoo*). The whole property of 200 acres was also cleared of underbrush.

The total expenditures of the Civilian Conservation Corps on this property were approximately $6,000. There have been few investments which have shown the return in obvious physical improvements equal to this work of the Civilian Conservation Corps at Las Mesas.[4]

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[3] It is a pleasure to express appreciation to the officers of the Puerto Rico Emergency Relief Administration not only for the appropriation of funds but also for the constantly evidenced spirit of cooperation.

[4] It is a pleasure to express appreciation to the Forestry Service of the Department of Agriculture and Commerce of the insular government and the Forest Service of the U. S. Department of Agriculture for this contribution which has so greatly increased the physical value of the Las Mesas property.

Additional allocation and use of special funds made available to station.

On April 24, 1935, the Secretary of Agriculture, with the approval of the President, authorized the allocation of $113,000 to the experiment station from the funds accruing from the processing tax collected in the sale of Puerto Rican sugar. The order allocating these funds specifies that they are to be used "for experimentation in the propagation and breeding of tropical plants and studies of animal parasites."

In May the director of the station conferred in Washington with the Chief of the Office of Experiment Stations, James T. Jardine, concerning the projects upon which these funds were to be expended.

Plans have been drawn up and approved for the development of the following projects: Studies of drug and insecticidal plants furnished in large part by the Bureau of Plant Industry, particularly tropical plants producing the insecticide rotenone; agricultural engineering studies to improve the methods for the utilization of bamboo and to study and improve upon some of the types of agricultural machinery used in the Tropics; an expansion of the work of introducing new economic crops from other tropical countries; an expansion of work upon sugarcane agronomy and physiology; further studies in sweet corn breeding, culture, and shipping; breeding studies and culture of long-staple cotton; studies of truck-crop gardening and marketing, with winter crops particularly in view; studies of the production and processing of vanilla; horticultural and marketing studies of such tropical fruits as mangoes, mangosteens, and papayas; studies of field tillage and cultivation methods in relation to aeration and plant growth; and studies of the parasites of domestic animals.

The organization of the foregoing projects was being initiated as the fiscal year terminated.

ACTIVITIES OF BUREAUS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE IN PUERTO RICO

Although the experiment station has been able to contribute little more than a cordial attitude of cooperation to the activities of other Bureaus of the Department in Puerto Rico, it has been suggested that a review of the work of the year would not be complete without mention of some of the activities carried on by such other agencies of the Department.

This experiment station serves as a tropical trial ground for the Division of Plant Exploration and Introduction of the Bureau of Plant Industry, which perhaps has the best organization and greatest resources in the world for securing valuable economic plants and new ornamentals from remote countries. The plant introductions which this division arranges are clearly beneficial to Puerto Rico as well as to the subtropical areas of the continental United States.

The Bureau of Entomology and Plant Quarantine has maintained a laboratory at the station for the study of the two species of West Indian fruit fly, *Anastrepha acidusa* Walk. and *A. supensa* Loew. The Mayaguez laboratory is one of four fruit-fly laboratories maintained by the Bureau in Mexico, Hawaii, and the Canal Zone for the study of fruit flies and their natural enemies. These fruit flies are a

severe handicap to the development of several fruit industries in this island and it is already apparent that the work of the Bureau of Entomology and Plant Quarantine is clearing the way for several fruit crops of high value per acre, which can contribute in a large measure to the rehabilitation of Puerto Rico. Towards the close of the year work on the installation of equipment for experiments on the sterilization of fruits by high and low temperatures was started at the station. Through an allotment obtained by the director of the station from the F. E. R. A. of Puerto Rico, labor and certain materials were furnished for this entomology project.

The station also furnishes office and laboratory space for a representative of the plant quarantine service of the same Bureau, and can thus observe the precautions which are being taken to protect the agricultural interests of the continental United States as well as Puerto Rico against the importation of new foreign insect pests and diseases.

The Bureau of Animal Industry, Division of Tuberculosis Eradication, began the eradication of bovine tuberculosis in Puerto Rico during the year. This station has been able to contribute little more than office space and verbal encouragement to this project, yet has been able to see the progress already achieved. The district of Mayaguez, in which the experiment station is located, has been the first to be accredited as practically free of bovine tuberculosis, as a result of this campaign of the Bureau of Animal Industry.

The Bureau of Chemistry and Soils for 3 years has been conducting a soil survey and preparing maps of the soil types, covering the whole of Puerto Rico. There has been no contribution which this station could make to this work other than a desire to be helpful; on the other hand, the Bureau has prepared a careful soil survey and map of the lands of the station which has been of fundamental value in selecting fields of representative soil types for experiments. The completion of the survey and soil map of Puerto Rico by the Bureau will be a major contribution to the agricultural and consequent economic rehabilitation of Puerto Rico. Already the results of the partial surveys are being advantageously used by the rehabilitation and reconstruction organizations as well as permanent agricultural entities.

The Bureau of Agricultural Economics has continued to maintain its representative in the island to aid in the standardization of agricultural products as well as the submission of reports of crop conditions. This service has saved material sums of money for fruit and vegetable shippers.

The relations with the Forest Service have been very close, arising from the interchange of seeds and plants, but with no necessity of a formal agreement of cooperation. Cordial appreciation should be and is here expressed to the Forest Service for its direction of the C. C. C. laborers on the Las Mesas property in the work of reforestation and trail construction. The activities of the Forest Service of the Department cooperating with the Insular Forest Service have resulted in many unproductive areas of land being reforested, an essential measure in the rehabilitation of Puerto Rico.

During the year Louise Stanley, Chief of the Bureau of Home Economics, visited the island and contributed substantially to the orientation of projects to be undertaken by the station. There is

urgent necessity for studies in the field of home economics which no agency either insular or Federal has adequate resources as yet to attempt.

The Weather Bureau has developed and completed one cooperative project with this station during the year, a study and preparation of graphs showing average annual rainfall distribution at 36 rain-recording stations in the island. Bound volumes of these graphs have been in great demand and evince the value which the progressive elements of the public place on the accurate records and averages of the Weather Bureau, upon which rainfall expectations may be calculated.

CHANGES IN PERSONNEL

In June 1934, T. B. McClelland, then director and horticulturist of the station, accepted the position of superintendent of the Plant Introduction Garden, Bureau of Plant Industry of the United States Department of Agriculture, located at Coconut Grove, Fla. He was succeeded as director by Atherton Lee on July 3, 1934. On June 10, 1935, Claud Horn, formerly of the Virgin Islands Experiment Station of the United States Department of Agriculture, was appointed associate horticulturist in charge of plant introductions.

At the close of the fiscal year other appointments were under consideration.

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